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THE AUTOMATIC ROOM VENTILATION SYSTEM

Abstract: Stuffy rooms are a common problem in our daily life. Carbon dioxide, which people constantly produce, makes the rooms stuffy. In such rooms work productivity goes down, people start feeling sleepy, irritated and often get a headache. Excess in the amount of carbon dioxide is harmful to health. Therefore, it is very important to ventilate the stuffy rooms and let fresh air with oxygen replace carbon dioxide especially in sleeping rooms. The automatic room ventilation system is designed to control air quality without additional actions from users. The system will automatically open the windows or turn on active ventilation if the amount of carbon dioxide is exceeded, which will be measured by the sensor.

This article describes the main parts of the automatic ventilation system such as a CO₂ sensor and its measurement features, microcontrollers with LoRa technology and a gateway as the main server. Also, the communication protocol MQTT as well as the two types of ventilation systems: passive (or natural) and active (or mechanical) are described. In conclusion, a full concept of the system is presented.

Keywords: IoT, Internet of Things, CO₂, MQTT, LoRa, ventilation, Samsung.

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СИСТЕМА АВТОМАТИЧЕСКОГО ПРОВЕТРИВАНИЯ ПОМЕЩЕНИЯ

Аннотация: Душная комната – это частое явление в нашей повседневной жизни. Углекислый газ, который человек постоянно выдыхает, создает ощущение духоты. В душной комнате у людей снижается работоспособность, они чувствуют сонливость, раздражительность и головную боль. Избыток углекислого газа плохо влияет на здоровье, поэтому важно вовремя проветривать рабочие и жилые помещения, особенно спальные комнаты. Система автоматического проветривания помещения призвана контролировать качество воздуха без дополнительных действий со стороны пользователей. Такая система позволит автоматически открывать окна или включать активную вентиляцию при избытке углекислого газа, который будет регистрироваться сенсором.

В данной статье описаны основные части системы автоматического проветривания помещения, такие как датчик углекислого газа и его особенности, микроконтроллеры, считывающие показания датчиков и передающие их через технологию LoRa, и шлюз – главный сервер, осуществляющий управление системой. Также описан протокол MQTT, предназначенный для коммуникации устройств. Приведено описание двух типов вентиляции: пассивной (или естественной) и активной (или механической), указаны достоинства и недостатки каждой. В заключении представлено краткое обобщение материала для четкого понимания работы системы.

Ключевые слова: интернет вещей, CO₂, углекислый газ, вентиляция, MQTT, LoRa, Samsung.

The high level of carbon dioxide makes the room stuffy. According to Robertson D. S. [2] the effects of carbon dioxide are a reduction in the pH value of blood serum leading to acidosis. The minimum effects of acidosis are restlessness and mild hypertension. As the degree of acidosis increases, somnolence and confusion follow. One of the effects of these changes is unwillingness to indulge in physical and mental activity. For example, you can often see students sleeping at lectures. In some cases the reason is not because of the lecturer presenting boring material or the fact that the students had a sleepless night before, but because of the stuffy auditorium. In this article, we want to describe the automatic room ventilation system for a smart room.

CO₂ sensor

The most important part of the system is the sensor of carbon dioxide. In the system it is planned to use the sensor MH-Z19. Its technical parameters are presented in table 1. The measurement principle of this sensor is Non-Dispersive Infrared Technology (NDIR), which is independent of oxygen.

Table 1 – Technical Parameters of sensor MH-Z19

Measuring Range	0 ~ 2000 ppm / 0 ~ 5000 ppm
Accuracy	± (50 ppm +5 % reading value)
Working temperature	0 ~ 50 °C
Output signal	UART / PWM
Working voltage	3.6 ~ 5.5 V DC
Lifespan	> 5 years

CO₂ concentration is measured in ppm. In the article «How Climate Change Is Ruining Our Indoor Air» [3] the author states that many of us at home, at school, and at work breathe in the air containing CO₂ concentrations of 1,000 ppm every day. Badly ventilated classrooms and overcrowded conference rooms can reach 2,000 ppm, well above the point when the air becomes «stuffy», at 600 ppm.

The CO₂ sensor transmits data to a microcontroller via UART interface.

Microcontrollers

The microcontroller receives information from the sensor and processes it. In addition, it communicates with the gateway by sending measurement results or receiving control commands. A good option would be Unwired Range microcontroller from Unwired Devices, which has

LoRa on board. The microcontroller and the gateway will exchange information via LoRa technology because it has low power consumption [1].

Gateway and MQTT

Gateway is the main part of the system, i.e. its brain. It controls other devices and connects with the outside world. MQTT is a protocol and a platform for communication between the devices, where smart devices publish messages and subscribe to topics of interest to them. For example, Figure 1 shows a diagram of the ventilation system and the process of fan activation after receiving the message from the CO₂ sensor.

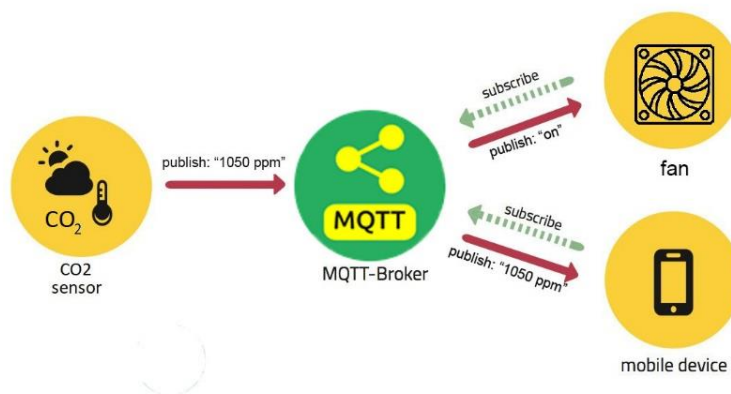


Figure 1 – MQTT protocol and device interaction

Their chat can be presented as follows (topic and message):

- classR325/CO2/data «1050» (message from CO₂ sensor, 1050 ppm)
- classR325/fan/command «on» (message from gateway for the fan)
- classR325/fan/status «on» (the fan changed its state)

In this context, the fan is the airing system, which is used in the room.

Ventilation systems

Two types of systems can be used for room ventilation: passive and active.

The passive system is natural airing when people open the windows, doors or other doorways. The microcontroller can open and close the window by operating an electric drive. The example of a «Smart window» is shown in Figure 2.



Figure 2 – «Smart window» with a drive

The advantages of the passive ventilation are that it is not noisy and it has small cost, but in the warm season there is a problem as at daytime the airing will raise the temperature in the room and it will not be comfortable for people. In this case, you need to ventilate the room at night.

An alternative option is the active (or mechanical) ventilation by using exhaust and intake fans. In this system, the microcontroller can control fans flexibly. Such a system will air the room faster than the passive ventilation, but it has a high cost. Upgrading the existing system would be an excellent option.

To summarize, a high concentration of carbon dioxide is harmful to health of people, so the rooms need constant airing. The automatic system allows monitoring the air condition and controlling the ventilation system without human intervention.

The system has the CO₂ sensor, two microcontrollers with LoRa technology, the gateway with MQTT server and the ventilation system. The CO₂ sensor measures carbon dioxide levels, transfers its measurements to the microcontroller, which then sends them to the gateway. The gateway controls the state of the ventilation system, sending control commands to the second microcontroller, which opens or closes the window or turns fans on or off.

In the future, it is planned to implement this system and study its effect on the human condition.

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